ANCIENT HYDROTHERMAL SPRINGS IN ARABIA TERRA, MARS. Dorothy Z. Oehler[1] and Carlton C. Allen[1]. [1]NASA-Johnson Space Center, Houston, TX 77058. dorothy.z.oehler@nasa.gov, carlton.c.allen@nasa.gov.

Introduction: Hydrothermal springs are important astrobiological sites for several reasons: 1) On Earth, molecular phylogeny suggests that many of the most primitive organisms are hyperthermophiles, implying that life on this planet may have arisen in hydrothermal settings [1-3]; 2) on Mars, similar settings would have supplied energy- and nutrient-rich waters in which early martian life may have evolved [4-7]; 3) such regions on Mars would have constituted oases of continued habitability providing warm, liquid water to primitive life forms as the planet became colder and drier [8]; and 4) mineralization associated with hydrothermal settings could have preserved biosignatures from those martian life forms [9-11]. Accordingly, if life ever developed on Mars, then hydrothermal spring deposits would be excellent localities in which to search for morphological or chemical remnants of that life.

Previous attempts to identify martian spring deposits from orbit have been general or limited by resolution of available data [12-14]. However, new satellite imagery from HiRISE has a resolution of 28 cm/pixel which allows detailed analysis of geologic structure and geomorphology. Based on these new data, we report several features in Vernal Crater, Arabia Terra that we interpret as ancient hydrothermal springs.

Spring-like Features: Vernal Crater is a 55-km-diameter, Noachian impact structure, centered at 6°N 355.5°E, in SW Arabia Terra. The features interpreted as spring deposits occur within a dark geomorphic unit in the southern portion of the crater (Fig. 1). The deposits are light-toned, elliptical features, ~200m wide by 450 to 550m long, with low relief and apical depressions (Figs. 2-5). They have bright, terraced and asymmetric flanks, double concentric tonal anomalies having circumferential curved faults, and are associated with flat-topped outcrops, river-like channels, and two regional fracture sets. The fracture sets are composed of multiple linear faults that pre-date the mounds. Two prominent spring-like features have been identified and each displays all of the characteristics listed above. Several additional, though less well defined, examples occur as well.

Discussion: The spring-like features are interpreted as low mounds, based on enhanced brightness on their western (sun-facing) sides. Neither feature exhibits a detectable shadow in HiRISE imagery, indicating that local slopes do not exceed the sun angle of 34° above the horizon. Each mound has a circular depression, at a location interpreted as the apex.

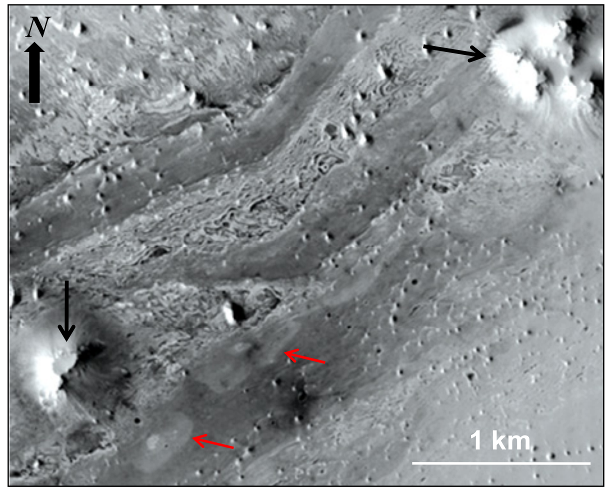

Fig. 1. Spring-like mounds with surrounding tonal anomalies (red arrows). Mesa-like outcrops (black arrows). All figures from HiRISE image PSP_002812_1855.

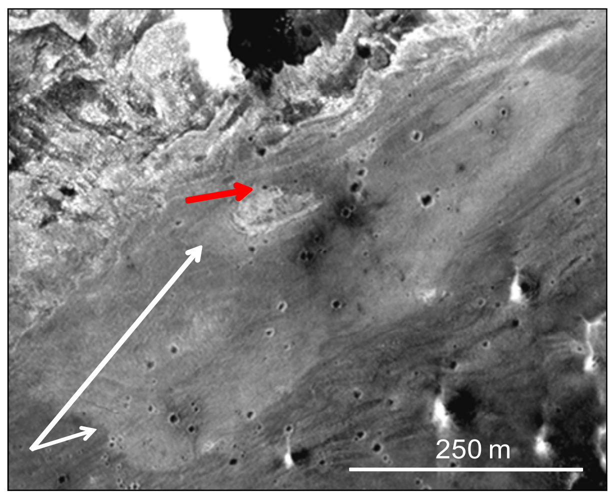

Fig. 2. East mound: inner and outer tonal anomalies (white arrows) and terraced side with apical depression (red arrow).

The martian structures have a striking similarity to terrestrial hydrothermal spring mounds, such as those at Dalhousie, Australia [15-17]. Analog features include size, shape, tonal anomalies, apical depressions, lateral terraces, asymmetry, and association with river-like channels, mesas, and regional faulting.

The areal density of 5-25 m-diameter craters on each martian mound is approximately 150 per km^2, suggesting that the two features are roughly contemporaneous, with maximum surface ages of approximately 100 my [18]. This implies that the terraced mounds must be indurated and cemented to have survived millions of years of wind erosion.

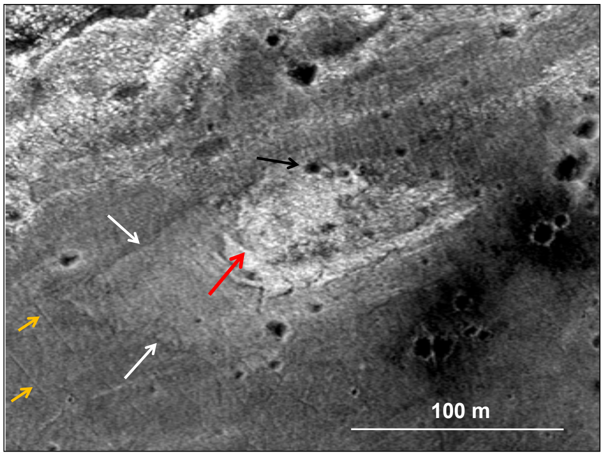

Fig. 3. East mound: inner tonal anomaly (white arrows), bright terrace (red arrow), apical depression (black arrow), linear faults (orange arrows).

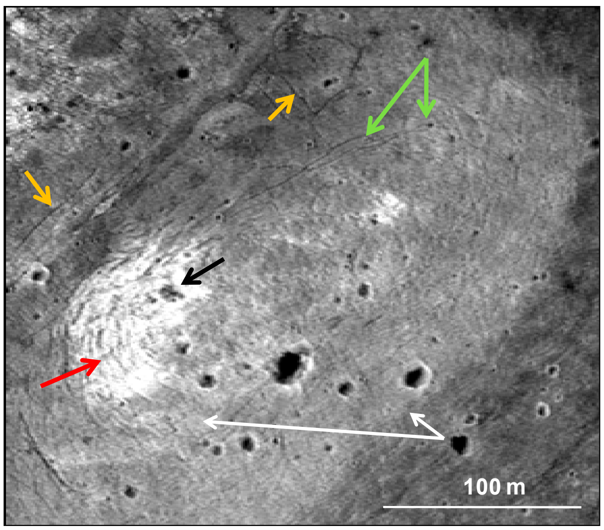

Fig. 4. West mound: bright terraces (red arrow), circumferential, curved fractures (green arrows), and linear fractures of regional fracture sets (white arrows).

The elliptical shapes of the tonal anomalies and the fact that both mounds display two concentric halos suggest that anomaly formation has involved either surface evaporation of pooled liquids during earlier stages of mound growth (as occurs at Dalhousie) or a subsurface reaction front between fluids and the host sediments. Either case implies the past presence of liquid water. This conclusion is supported by the evidence for cementation and by the numerous associated channels that resemble surface rivulets and sapping gullies at Dalhousie (Fig. 5). Since liquid water probably has not been stable on the surface of the planet since the late Noachian/Early Hesperian, it is likely that subsurface flow brought comparatively warm waters to colder, shallower settings and thus that the springs were hydrothermal with respect to local geology.

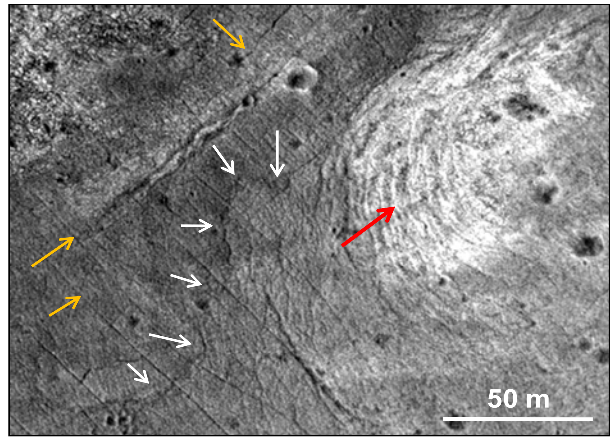

Fig. 5. West mound: river-like channel (white arrows), linear faults (orange arrows), and bright terraced flank (red arrow).

Implications: Identification of ancient thermal springs on Mars is of major importance, as these could be sites where martian life evolved, sought refuge as the climate became colder and drier, and may be preserved. The recent report from the Spirit rover of silica which has been attributed to fumarolic or hot spring activity [19-20] supports the concept of hydrothermal activity within martian impact craters. Our identification of several spring mounds in Vernal Crater suggests that this was a significant hydrothermal province, perhaps owing its existence to regional fractures which facilitated upward flow of warm waters. The young, ~100 my age of the mounds has bearing on our understanding of the geothermal history of Mars. Finally, our results provide a template that can be used to search for similar features elsewhere on the planet.

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